Liquidity, Liquidity Spillover, and Credit Default Swap Spreads *

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ABSTRACT

This paper provides the first empirical study of the effects of liquidity in the credit default swap (CDS) market and liquidity spillover from other markets on CDS spreads. We use three CDS liquidity proxies: total number of quotes and trades, order imbalance, and bid-ask spread. The liquidity effect in the CDS market is more significant than generally believed. We estimate an illiquidity premium of 9.3 basis points in CDS spreads, on par with the Treasury bond liquidity premium and the nondefault component of corporate bond yield spreads. There is significant liquidity spillover from bond, stock and option markets to the CDS market. As the CDS market liquidity improves over time, the liquidity and liquidity spillover effects become weaker in more recent periods. These results provide a new perspective for a better understanding of the CDS markets and previous findings on CDS spreads.

JEL Classification: G12; G13; E43; E44

Keywords: Credit Default Swaps; Credit Spreads; Liquidity; Liquidity Spillover

Preliminary. Comments Welcome!

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ABSTRACT

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I. Introduction

The credit default swaps (CDS) market has grown rapidly in the past decade. Much of this development stems from the demand from banks and insurance companies to hedge their underlying bond exposures and the need for more liquid instruments for speculation on credit risk by hedge funds and investment banks' proprietary trading desks. Blanco, Brennan, and Marsh (2005) report evidence that the CDS market is more liquid than the corporate bond market because the price discovery in the CDS market tends to lead the bond market. This finding is corroborated by the evidence of insider trading in the credit derivatives market documented in Acharya and Johnson (2005). Because of the perceived lack of liquidity (and tax) concerns in the CDS market, several recent papers have used CDS spreads as a more direct measure of credit spreads attributable to default risk. These papers include Berndt, Douglas, Duffie, Ferguson and Schranz (2005), Ericsson, Reneby and Wang (2005), Longstaff, Mithal, and Neis (2005) and Pan and Singleton (2005).

The trading in the CDS market, however, is sparse. On average, each issuer has about one trade or quote per trading day. While Longstaff, Mithal, and Neis (2005) articulate that liquidity concern may be less severe in the CDS market due to the contractual nature of credit default swaps, it does not mean that liquidity in the CDS market can be ignored. On the contrary, existing empirical findings are indicative of a sizable liquidity effect in the CDS market. For example, 19 of the 33 reference entities studied by Blanco, Brennan, and Marsh (2005) have average CDS spreads larger than their corresponding corporate bond yield spreads. This would be unlikely if CDS spreads contain no illiquidity premium and reflect only credit risk. Pan and Singleton (2005) find that, without considering the liquidity effect in the CDS market, the recovery rate implied by the term structure of sovereign CDS spreads is significantly lower than generally observed. They also show that the pricing error is particularly large for short-term (1-year) CDS contracts and suggest a second factor which may be related to liquidity in these contracts due to trading pressure. Berndt *et al* (2005) find that there is on average approximately 33 basis points in CDS spreads that are not accounted for by default risk measured by the Moody's KMV's EDF indicator. Moreover, from the information-theoretic view, with informed trading in the CDS market (e.g., Acharya and Johnson (2005)),[1] asymmetric information and associated risk of adverse selection will lead to widened bid-ask spreads in this market and

[1]Even in the absence of asymmetric information, incomplete information characterized by the lack of transparency has been shown to affect corporate bond yield spreads by Duffie and Lando (2001) and Yu (2005a). This effect may also affect CDS spreads as liquidity can deteriorate for CDS contracts of firms with an opaque information environment.

increase liquidity costs of trading.[2] Therefore, it is important to analyze explicitly the liquidity effects on CDS spreads.

In this paper, we investigate how liquidity in the CDS market affects CDS spreads. We use three different measures to proxy for the liquidity in the market. The first measure is the total number of quotes and trades per month (NQT) for each contract. Because a majority of trades in credit default swaps are done in order to obtain protection on credit risk, dealers are often the main liquidity providers in the market by providing such insurance and holding large portfolios of swaps. Therefore, a higher level of NQT actually implies higher demand for credit protection and hence worsening marginal liquidity in the market. This notion is corroborated by the second measure we use, order imbalance, which is constructed by using the Lee-Ready (1991) algorithm to assign a trade direction for each quote or transaction. The correlation between NQT and order imbalance is 0.57. The third measure is the bid-ask spread, which captures the cost for dealers to provide liquidity to the market.

We find that, controlling for fundamental determinants of credit spreads, CDS spreads are significantly positively related to NQT, the measure of total market activity. Because NQT actually captures the trade imbalance and hence decreases in marginal liquidity, this implies that there is a significant liquidity effect in the CDS market. In fact, the implied illiquidty premium is about 9.3 basis points, on par with the 5-year Treasury illiquidity premium of 9.99 basis points estimated by Longstaff (2004) and the average size of the non-default component of corporate bond spreads (8.6 basis points) estimated by Longstaff, Mithal, and Neis (2005) using swap curves. We also find that the order imbalance measure and the bid-ask spread provide the same qualitative result. These findings represent the first systematic evidence that demonstrates the importance of liquidity consideration in the CDS market.

Corporate bondholders averse to default risk may want to enter CDS contracts for credit protection if selling the bonds is too costly due to illiquidity in the corporate bond market.[3] The illiquidity in the bond market can also affect dealers' hedging capability and hence increase the premium embedded in CDS spreads. Therefore, when the underlying bonds have poor liquidity, *ceteris paribus*, the corresponding CDS spread should be higher. We investigate this liquidity spillover from the bond market to the CDS market. Following the suggestion by Edwards,

[2] Acharya and Johnson (2005) do not find a significant liquidity effect in CDS market. They use a set of "benchmark" CDS issues which are arguably the most liquid CDS in the market. We use a database with a broader set of CDS contracts to mitigate the potential bias in sample selection.

[3] There are other reasons that bondholders cannot sell the bonds. For example, a bond underwriter may agree to hold the bond they underwrite for certain period. Holders of convertible bonds will not want to sell the bonds because they like the convertibility portion of the security. Many of them may want to obtain credit protection by entering into CDS contracts.

Harris and Piwowar (2005), we measure the liquidity of a corporate bond by its age, maturity and issue size. Consistent with our conjecture, we find that CDS spreads are lower for bonds with a large issue size and higher for longer-term bonds. However, we don't find a significant effect for the vintage of a bond.

One trading strategy that has become popular with hedge funds and investment banks in recent years is capital structure arbitrage, which exploits potential relative price inefficiencies among equity and debt instruments of the same firm (see, e.g., Yu (2005b)). The development of the CDS market helps fuel the deployment of this strategy by providing a more efficient way to trade in credit risk than the corporate bond market. In order to implement their strategies, credit traders often trade credit default swaps simultaneously with corresponding equity securities. Then the price formation in the CDS market depends on the liquidity of equity markets. For example, if an investor wants to build a portfolio with both stocks and CDS contracts because of her private information, she may not trade CDS contracts at all if her stock or stock option positions are too costly to build. Given that most of hedge funds are liquidity providers in the CDS markets, liquidity in other markets will allow them to execute their trades in the CDS market and thus reduces CDS spreads.

We examine this hypothesis of liquidity spillover from equity and equity option markets to the CDS market. We use the Amihud (2002) measure to measure the illiquidity of the corresponding stock. Option liquidity is measured by bid-ask spread, trading volume and open interest. We find that controlling for fundamental determinants and NQT, the effect of stock illiquidity on CDS spreads is significantly positive. Moreover, our empirical results indicate that, *ceteris paribus*, CDS spreads are lower if the underlying firm's stock options have a higher trading volume, or a narrower bid-ask spread. While in the univariate regression, an option's open interest has no effect on CDS spreads, it is significantly positive in a multivariate regression, because the unique effect of divergence in opinion comes through once the trading volume controls for the market activity in the underlying option.

In addition, we document improving liquidity in the CDS market over time, as the market has undergone tremendous growth and maturation. We show that the average trading cost, measured by the average bid-ask spread, has decreased significantly over time. We also illustrate that the explanatory power of liquidity measures for CDS spreads, proxied by R^2s of the regression of CDS spreads on these liquidity measures, have declined from a very high level (~ 0.8) and stabilized to a level around 0.3. This observation of time variation of the liquidity effect may provide a perspective for understanding the result in Berndt *et al* (2005), which shows that the default risk premium estimated based on CDS spreads has decreased by almost 50%

from the third quarter of 2002 to late 2003. This time variation in the credit risk premium may be consistent with a constant default risk premium and a reduction in the illiquidity premium, as the CDS market has become more liquid in more recent years.

To our best knowledge, our study is the first to focus on the liquidity and liquidity spillover in the CDS market, although the liquidity effect has been extensively studied for the corporate bond market.[4] Ericsson and Renault (2005) and Chen, Lesmond, and Wei (2005) have analyzed the liquidity effect in corporate bond yield spreads. Regarding liquidity spillover, Odders-White and Ready (2006) show that credit ratings are related to equity market liquidity. Moreover, Newman and Rierson (2004) demonstrate liquidity spillover in the Euro Telecom industry.

Our unique contribution in this paper is to provide strong evidence to illustrate the significant effect of liquidity in the CDS market on CDS spreads which supports the consideration of a liquidity factor in order to account for unexplained discrepancies in CDS spreads, documented in Berndt *et al* (2005), Blanco, Brennan, and Marsh (2005), and Pan and Singleton (2005). We further show that there are significant liquidity spillovers from other markets into the CDS market, demonstrating the integration among these markets and the important role of liquidity in such market integration. A good understanding of the CDS market structure is important for financial market stability. Duffee and Zhou (2001) raise some concerns on the usage of CDS contracts. Recent episodes in the CDS market involving credit downgrades of General Motors and Ford and associated huge losses incurred by hedge funds trading in the CDS markets have led to much turbulence in the entire financial market, with some investors fearing a LTCM type of market collapse. Our study should help shed more light on the CDS markets and its interaction with other markets and inform on policy implications.

The rest of this paper is organized as follows. Section II provides some background information on the CDS market and describes the CDS data used for this study. Section III discusses the control variables and the econometric method used for our empirical analysis. Section IV demonstrates the liquidity effects in the CDS market. Section V presents evidence of liquidity spillover effects from bond, stock and option markets to the CDS market on CDS spreads. Section VI illustrates the time variation in the liquidity effect. Section VII concludes.

[4] The relevance of liquidity for derivative securities is discussed by Jarrow (2005) and Jarrow and Protter (2005). Important contributions are also made by Cetin, Jarrow, Protter, and Warachka (2005) on incorporating liquidity risk into option pricing.

II. Credit Default Swaps (CDS): Background and Data

A. The CDS Market

Credit derivatives markets have been growing rapidly. The notional amount traded in global credit derivatives markets had increased from \$180 billion in 1997 to \$5 trillion in 2004 and is expected to rise to \$8.2 trillion by the end of 2006, according to a new report, based on a survey based on 30 market leaders, published by the British Bankers' Association (BBA). Increased market liquidity, improved standardization within the market and a greater understanding by clients have all been instrumental in the rapid growth of the global market in credit derivatives. Most credit derivatives are unfunded, i.e., they do not require up front capital investment. Banks, securities houses and insurance companies constitute the majority of market participants. Recently, hedge funds have emerged to be an important player in credit derivatives markets.

Nearly half of the instruments traded in the credit derivative market are related to credit default swap contracts. Credit default swaps are over-the-counter contracts for credit protection. CDS contracts were developed by banks in order to reduce their credit risk exposure and better satisfy regulatory requirements. In a CDS contract, the two parties, protection buyer and seller, agree to swap the credit risk of a bond issuer or loan debtor ("reference entity"). Credit protection buyer pays a periodic fee (CDS premium or spread) to the protection seller until the contract matures or a credit event occurs, in which case the protection buyer delivers defaulted bonds or loans ("reference issue") to the seller in exchange for the face value of the issue in cash ("physical settlement"), or the protection seller directly pays the difference between market value and face value of the reference issue to the protection buyer ("cash settlement"). Credit event and deliverable obligations are specified in the contract. Credit events generally include bankruptcy, failure to pay, and restructuring. Along with the development of the CDS market, International Swaps and Derivatives Association (ISDA) has given definitions to four types of restructuring: full restructuring; modified restructuring (only bonds with maturity shorter than 30 months can be delivered); modified-modified restructuring (restructured obligations with maturity shorter than 60 months and other obligations with maturity shorter than 30 months can be delivered); and no restructuring.

The typical maturity of a CDS contract is five years. The typical notional amount is \$10-20 million for investment grade credits and \$2-5 millions for high yield credits. CDS trading is concentrated in London and New York, each accounting for about 40% of the total market. Most transactions (86%) use physical settlement, according to the 2003/2004 Credit Derivatives

Report by the British Bankers' Association.

B. CDS Pricing: Models and Evidence

CDS spreads are the compensation for investors providing insurance for default risk. CDS pricing is similar to corporate bond pricing in capturing the risk of default and the potential loss upon default. Duffie (1999) provides a practical overview of CDS valuation. Two approaches are used for credit risk modeling. The structural approach, or Merton (1974) models, describes default as the first-passage of firm value below a threshold. The reduced-form approach, originated by Jarrow and Turnbull (1995), attributes default to some exogenous inaccessible intensity process. The fundamental difference between structural and reduced form models is driven by the information set available to the modeler. In structural models, the modeler has perfect information regarding the firm's asset value, while this restriction is not imposed on reduced form models. Structural models converge to reduced form models when this perfect information assumption is relaxed (Duffie and Lando (2001), and Guo, Jarrow, and Zeng (2005)). The relationship between these two approaches is discussed in detail by Jarrow and Protter (2004). Which model to use depends on the problem at hand. The reduced form models have a better chance fitting the observed credit spreads because they have fewer constraints. But it is unclear which approach has better forecasting power.

Current empirical evidence indicates that both structural and reduced form models perform well in explaining CDS spreads. Leland (2004) shows that structural models can predict default probability well. Berndt *et al* (2005) find that default probabilities, measured by Moody's KMV's Expected Default Frequencies (EDF), can explain a large portion of CDS spreads. Ericsson, Reneby, and Wang (2005) find that corporate yield spreads contain significant liquidity premium while credit default swap (CDS) spreads do not. Ericsson, Jacobs, and Oviedo (2005) show that factors suggested by structural models are important determinants of CDS spreads. Houweling and Vorst (2005) show that CDS spreads can be well explained by simple reduced form models. While reduced form models render modeling convenience, Arora, Bohn, and Zhu (2005) find that reduced form models do not outperform structural model when predicting the probability of default and the CDS spreads.

A critical factor in credit risk portfolio management is default correlations. Das, Duffie, Kapadia, and Saita (2005) and Zhang (2005) demonstrate contagion as a default trigger. Recovery rate plays another important role in CDS pricing. We believe a study on liquidity and liquidity spillover in the CDS market will shed more light on credit contagion and recovery process and improve our understanding of CDS pricing.

C. CDS Data

Our dataset is from a major CDS broker and spans from June 1997 to April 2005, representing the largest CDS database so far. It has information on all the intraday quotes and trades, including transaction time, reference entity (bond issuer), seniority of the reference issue, maturity, notional amount and currency denomination of the CDS contract, restructuring code, and the quote or trade price. In this study, we only use CDS prices for non-Sovereign U.S. bond issuers denominated in U.S. dollars with reference issues ranked senior and CDS maturities between 4.5 and 5.5 years. Monthly data are obtained by averaging over the month. All together, in our sample there are 10697 issuer-month CDS spread observations.

Average CDS spreads are plotted in Figure 1. There is significant time-series variation in average CDS spreads. CDS spreads peaked in the second half of year 2002 due to the credit market turbulence at the time. CDS spreads subsequently declined afterwards possibly due to (1) improving macroeconomic conditions that lead to lower market-wide credit risk; (2) more dominance of high quality issuers in the market; (3) increased competition in the market such that CDS sellers could not overprice the CDS contracts.

Figure 2 plots the monthly total number of quotes and trades in our data sample. It shows that there was little trading prior to 1999, because our data provider was one of the handful of earliest market participants. The shrinking trading activity in our data sample since 2003 reflects the increasing competition from other dealers and new entrants in this market, as a new player emerges every several months. It is widely perceived that the market is much more competitive and liquid than the early stage of the market.

Table 1 provides the year-by-year summary statistics for our data sample. In our sample, average CDS spreads over the entire sample is 125.73 basis points. The majority of CDS contracts are for A and BBB bonds. Two observations from the summary table are noteworthy. First, The average spread for AAA bonds is about 35 basis points, which is still much higher than predicted value by most structural models. Second, CDS spreads for AAA bonds are not always smaller than CDS spreads for AA bonds, which suggests that CDS spreads may contain components other than credit risk. Other factors such as liquidity may also at work. Alternatively, CDS spreads may react to news more promptly than credit ratings. As shown by Hull, Predescu, and White (2004) and Norden and Weber (2004), the CDS market anticipates rating announcements, especially negative rating events. For AAA bonds, the only possible rating change is downgrade. Therefore, the market could incorporate information before rating agencies adjust the ratings.

III. Control Variables and Empirical Methodology

The purpose of our study is to examine the effects of liquidity and liqudity spillover. To isolate the effects of liquidity and liquidity spillover, we control for other fundamental determinants of CDS spreads and adopt an appropriate econometric framework.

A. Fundamental Determinants of Credit Spreads

We identify the set of credit risk factors that are commonly studied in the literature (see, among others, Collin-Dufresne, Goldstein, and Martin (2001), Campbell and Taskler (2003) and Eom, Helwege, and Huang (2004)). Those factors affect credit spreads either through default probabilities or through expected recovery rates. Although most theoretical models assume a constant recovery rate, empirical evidence has shown that recovery rate varies across industries and with time. It is necessary to control for those factors in order to isolate the unique effects of liquidity and liquidity spillover effects that are not due to correlations with fundamental factors.

The Merton (1974) model suggests leverage ratio and asset volatility as the only cross-sectional determinants of default probabilities (DP). Leland (2004) argues that in order to better match historical default probabilities, a jump component is needed for the asset value process. Driessen (2005) estimates a reduced form model and uncovers a significant jump risk premium. Therefore, our first set of credit risk factors should include leverage, asset volatility, and jump component in asset value. In theory, credit spreads should increase with leverage, asset volatility, and jump magnitude.

We measure leverage using book value of debt and market value of equity, as following:

$$\text{Leverage} = \frac{\text{Book Value of Debt}}{\text{Market Value of Equity} + \text{Book Value of Debt}}. \tag{1}$$

This is the measure customarily used in the literature. The market value of equity is calculated as stock price multiplied by number of shares outstanding. The book value of debt is the sum of short-term debt (Compustat quarterly file data item 45) and long-term debt (item 51). Debt level is only available at quarterly frequency. Following Collin-Dufresne, Goldstein, and Martin (2001), we use linear interpolation to obtain monthly debt levels based on quarterly data.[5] When this interpolation results in a negative debt level, we keep the previous debt level.

Asset volatility is not directly observable. In a simplified framework, asset volatility should be proportional to stock volatility. Therefore, we use instead stock return volatility measured by the average monthly at-the-money stock option implied volatility calculated based on option data from OptionMetrics. Option implied volatility measures total equity volatility, including idiosyncratic volatility. Campbell and Taskler (2003) show that idiosyncratic volatility can explain as much cross-sectional variation in credit spreads as can credit ratings. Cremers, Driessen, Maenhout, and Weinbaum (2005) argue that option prices contain information for credit spreads. These results further bolster the validity of using stock volatility as one of the fundamental control variables.

Asset value jump size is proxied by the monthly average slope of option implied volatility curve. Specifically, it is the difference between the implied volatilities at 0.9 strike-to-spot ratio and implied volatility at the money. The idea is that the skewness of the volatility curve is mainly caused by jump component. Similar measures of jump size are used by Collin-Dufresne, Goldstein, and Martin (2001), and Cremers, Driessen, Maenhout, and Weinbaum (2005).

Although credit rating does not directly enter into any structural credit risk model, we include credit rating for two reasons. First, credit rating has been shown to affect credit spreads even after controlling for leverage, volatility, and other factors. Second, Molina (2005) shows that, when leverage ratio is endogenized, the effect of leverage on credit risk is much larger than in the case of exogeneous leverage choice. Leverage ratio could be also chosen to target certain credit rating (Kisgen (2005)). Therefore, credit rating should have additional explanatory power as part of fundamental control variables. Credit rating is included in our CDS database. Missing values are filled in using data in Compustat and the Fixed Income Securities Database (FISD). Letter ratings are converted into numerical values as 37 minus the numerical number in Compustat, with AAA corresponding to 35, AA+ to 33, and D to 10. etc.

Lastly, we control for a firm's size and book-to-market ratio. Size and book-to-market ratio have long been argued to be associated with firm distress. Campbell, Hilscher, and Szilagyi (2005) show that book-to-market ratio and firm size are strong predictors of default probability,

[5] All of our results are not affected by this interpolation. Using quarterly leverage produces almost identical results.

especially for long run predictions.

B. Empirical Methodology

We conduct regression analysis to examine the effects of fundamental determinants on CDS spreads. We are primarily interested in the cross-sectional relation. Our dataset is a pooled time-series and cross-section unbalanced panel. Extra care needs to be taken to analyze such a panel dataset. Fama and French (2002) have expressed their concern on obtaining robust econometric inference from panel data by stating that "the most serious problem in the empirical leverage literature is understated standard errors that cloud inferences." Two types of correlations need to be considered in panel data: (1) Observations from the same issuer cannot be treated as independent to each other, therefore we need to control for the issuer effect; (2) Firms in the aggregate may be affected by the same macroeconomic condition, therefore we need to control for the time effect. Petersen (2005) provides a detailed analysis on the performance of various approaches in this setting. He shows that when the firm effect exists, adjusting for firm clustering is the preferred approach,[6] while when the time effect exists, Fama-MacBeth should be applied. When both firm and time effects are present, one may consider controlling time effect parametrically using time dummies with firm clustering.

Petersen (2005) states that "when the standard errors clustered by firm are much larger than the White standard errors (three to four times larger), this indicates the presence of a firm effect in the data. When the standard errors clustered by time are much larger than the White standard errors, this indicates the presence of a time effect in the data." Using this diagnosis, we find both firm and (relatively weaker) time effects in our panel data. Hence, we follow Petersen's suggestion and conduct our empirical analysis by adjusting for issuer clustering and controlling for the time effect by adding time dummies. We do not include any macroeconomic variables, and the time-series effect is controlled by monthly time dummies.[7]

[6] Petersen (2005) verifies that the bootstrapping method employed by Kayhan and Titman (2004) performed equally well.

[7] We have also entertained other approaches to obtain robust cross-sectional results. We first consider firm fixed effect rather than issuer clustering. For the second alternative approach we first calculate the time-series average for each issuer then we run one cross-sectional regression. In this way we suppress any time-series variations. Lastly we run cross-sectional regression for each month. The average coefficient and t values are then calculated by aggregating over all the months. This is the Fama-MacBeth approach which provides the most conservative results. All results are consistent with our issuer clustering-adjusted results.

IV. Liquidity and CDS Spreads

The notion that liquidity affects asset prices and returns is generally accepted since the seminal work of Amihud and Mendelson (1986), although the magnitude of the liquidity effect in asset markets is still being hotly debated. The contractual nature of credit default swaps makes liquidity or convenience yield a less serious concern. As argued by Longstaff, Mithal, and Neis (2005), CDS provides researchers with "a near-ideal way of directly measuring the size of the default component in corporate spread." However, like in any other markets, CDS market participants are not symmetrically informed. Liquidity costs induced by information asymmetry may affect CDS spreads. The magnitude of this liquidity effect is an empirical issue that we attempt to address here.

A. CDS Liquidity Proxies

Liquidity is an elusive concept. Often times liquidity has several distinctive dimensions. It is difficult to find a single summary measure for liquidity. Therefore, our objective is to find multiple proxies for liquidity to ensure the robustness of our findings. We use three measures for CDS liquidity: number of quotes and trades per month as a measure of trading activity; order imbalance; and bid-ask spread.

Our first and primary measure of CDS market liquidity is from market trading activity, the number of quotes and trades within a given month (NQT). Because we cannot identify the trade direction or calculate order imbalance, it is hard to tell whether high trading activity reflects more liquidity or the lopsided demand which would indicate illiquidty. Because CDS contracts provide protection against default risk, which is a downside event, it is arguable that demand for protection may be particularly high when a firm's financial condition deteriorates. Therefore, active trading may be linked to high order imbalance and less liquidity.

In order to formally verify the conjecture that CDS trading activity could be a measure for order imbalance, we use the Lee and Ready (1991) algorithm to assign trade direction. The Lee and Ready algorithm classifies a trade as buyer initiated if the trade price is above mid bid and ask price and seller initiated if trade price is above the mid price. Random direction is assigned if trade occurs at mid price. We find that the order imbalance measure so calculated has a correlation coefficient of 0.57 with NQT, thus confirming our conjecture that NQT is more related to marginal illiquidity. In our test, we use this order imbalance measure as another measure of CDS illiquidity.

CDS's are insurance contracts. Protection buyers and sellers agree on the terms of the contract. The most distinct difference between a CDS contract and a regular insurance contract, say, property insurance, is that CDS protection buyers do not have to hold the reference issue. CDS traders can nullify the CDS contract by taking the opposite position in a new CDS contract. Bid-ask spread represents the cost a trader needs to pay if she wants to unwind a position. Just as in any asset markets, bid-ask spread can also measure the degree of divergence of opinion or information asymmetry of the market. Therefore, bid-ask spread is a plausible proxy for liquidity in CDS market. We use percentage bid-ask spread (bid-ask spread divided by mid quote or trade price) to get a unitless measure. High bid-ask spread is associated with low liquidity.

B. Empirical Evidence

The effect of CDS liquidity on CDS spreads is shown in Table II.[8] In specification (1), NQT is used as an illiquidity measure. After controlling other credit risk and recovery factors, CDS spreads are positively significantly associated with NQT. Given the sample standard deviation of 58.11 for NQT, a one standard deviation increase in NQT is associated with 5.2 (58.11×0.09) basis points increase in CDS spreads. The economic significance of this illiquidity effect can be further seen by multiplying this 5.2 basis points to the current market nominal amount of CDS of $12.43 trillion (ISDA 2005 Mid-Year Market Survey), resulting a change of total CDS premium of $6.5 billion. Given the sample mean of 25.89 for NQT, the estimated liquidity premium is 2.3 basis points, comparable to the 9.99 basis points for the 5-year Treasury bond liquidity premium estimated by Longstaff (2004).

We obtain similar results using order imbalance (specification 2) and percentage bid-ask spread (specification 3) as illiquidity measures, albeit at lower significance levels. Our results on percentage bid-ask spreads are in contrast to the results in Acharya and Johnson (2005). They find an insignificant *negative* relation between CDS bid-ask spread and CDS spreads using a set of "benchmark" CDS contracts which are arguably the most liquid CDS contracts. In our study, we use market quote and trade data for all CDS contracts.[9] In specification (4) of Table II, we calculate the combined liquidity premium given the average percentage CDS bid-ask spread of

[8]The positive sign for market capitalization may seem puzzling, but it is consistent with the shareholders advantage story of Garlappi, Shu, and Yan (2005) that stems from the model of strategic debt service by Fan and Sundaresan (2000): controlling for credit risk, firms with more shareholder bargaining power (i.e., larger firms) will have higher credit spreads.

[9]Their sample is probably more homogenous as evidenced by the insignificant effect of leverage on CDS spreads.

0.23 as 12.29 bps. A more conservative estimate of total liquidity premium is 9.3 bps by adding the separate liquidity premium due to NQT (2.3) to the liquidity premium due to CDS bid-ask spread (7.0). Above results show that CDS liquidity affects CDS spreads. In the following analysis we will focus on the NQT measure it has the most data availability.

The liquidity effect may interact with credit risk. It is plausible that the magnitude of the illiquidity premium may vary across rating groups. For example, for high quality CDS names, the default probability is negligible, fewer investors are interested in such CDS contracts, therefore liquidity premium can be larger for high credit-quality names than for low credit-quality names. We separate the data by rating groups and examine the effect of NQT within each group. Regression results are presented in Table III. We consider four rating groups (AA, A, BBB, and BB) due to data availability. A pattern emerges from the coefficient estimates of NQT, which monotonically decrease from AA (0.26) to A (0.18) to BBB (0.16). The coefficient estimate is insignificant for BB (junk) group. Ericsson and Renault (2005) show that liquidity effect is more pronounced for lower credit-quality name in corporate bond market. The difference in the liquidity effects between bond and CDS markets could be driven by bond investors hedging needs using CDS contracts.[10]

Both Table II and Table III indicate that CDS spreads are well explained by credit risk, recovery risk, and liquidity. Regression R^2's are around 60% in Table II. Moreover, Lower credit quality CDS spreads are better explained than higher credit-quality CDS. In Table III, the R^2 for BBB bonds is substantially higher (0.562) than A's (0.312) even though the BBB group has more observations (4002) than A group (3176). This result provides indirect evidence that other factors are in place for high credit-quality CDS contracts.

V. Liquidity Spillover and CDS Spreads

CDS contracts are often traded jointly with other securities. It is likely that liquidity or illiquidity of other market could spill over to the CDS market. CDS contracts are used for two purposes: hedging and speculation. Bondholders may want to buy protection against default for the bonds in their portfolios when unloading the bonds are too costly due to bond market illiquidity. Some investors may also prefer bond-type securities to equity-type securities because their other portfolios are risky, they will choose CDS contracts over bonds if the bond market

[10]Other things to notice in Table III is that jump risk is only significant for lower credit-quality names. Leverage is *positively* related to CDS spreads for AA bonds. The book-to-marketratio is positively related to CDS spreads for AA names but negative for BBB names.

is illiquid. Those hedgers are mostly protection buyers. Their trading in the CDS market will increase order imbalance and reduce liquidity. Therefore bond market illiquidity could potentially affect CDS spreads by affecting CDS liquidity. Speculators, such as capital structure arbitrageurs,[11] trade CDS contracts jointly with equity-like securities such as stocks or options. In this case, stock (or option) liquidity is complement to CDS liquidity and will directly affect CDS apreads. Furthermore, CDS liquidity will be even stronger when the second channel is blocked as arbitrageurs are generally liquidity providers. They both buy and sell protections. In this section we examine the impact of liquidity spillover from bond, stock, and option markets on CDS spreads.

A. Liquidity Spillover from the Corporate Bond Market

A.1. Bond Liquidity Proxies

Edwards, Harris, and Piwowar (2004) argue that age, maturity, and amount outstanding are good measures of bond liquidity. Amount outstanding measures the availability of a bond. Recently issued or new bonds may be more liquid because they attract more of investors' attention. Bonds with shorter maturity may be more liquid because investors for long bonds may prefer the cash flow therefore not trade the bonds.[12] Because CDS contracts are written on certain bond classes (e.g., senior unsecured) rather than a specific bond issue, we use issuer average bond age, issuer average bond maturity, and issuer total bond amount outstanding to measure bond liquidity. The data is from the Fixed Income Securities Database (FISD).

A.2. Results

Table IV provides evidence of liquidity spillover from the bond market to the CDS market. From specification (2), we can see that CDS spreads are higher when the reference issue has longer maturity (a one standard deviation move in maturity is associated with 6.7 bps change in CDS spreads). Specification (3) shows issuers with more bond outstanding have lower CDS spreads (a one standard deviation move in bond principal outstanding is associated with 5.7 bps change in CDS spreads). The effect of bond age (specification (1)) is insignificant. This

[11]See Yu (2005b) for an excellent analysis of capital structure arbitrage.

[12]Another potential measure of bond liquidity is coupon rate. Bonds with high coupon may be less liquid because they are mostly held in the portfolios of investors who prefer the coupon payments. This argument is weaker in our case because we would have used the average coupon per issuer, which is homogeneous across all issuers.

lack of significance can be explained by familiarity effect: CDS investors are more familiar with issuers with older bonds, this effect offsets the liquidity spillover from older bonds.

From all four specifications we can see that, after including bond market liquidity proxies, both the magnitude of coefficient and statistical significance for NQT are reduced. The coefficient estimate decreases from 0.09 (in Table II model (1)) to 0.05. t values decrease from 2.55 to about 1.70. This result shows that if two firms have similar bond issues, CDS liquidity should not have a significant impact on CDS spreads. This liquidity spillover effect is consistent with the credit hedging scenario.

B. Liquidity Spillover from the Stock Market

B.1. Stock Liquidity Proxy

Firm i's stock liquidity in month m is proxied by the Amihud measure as monthly average absolute return over volume:

$$\text{Illiquidity}_{im} = \frac{1}{D_{im}} \sum_{d=1}^{D_{im}} \frac{|r_{id}|}{\text{Volume}_{id}}, \tag{2}$$

where D_{im} is the number of days in month m for firm i, r_{id} is day d's return, and Volume_{id} is day d's volume. This measure actually measures illiquidity rather than liquidity. Hasbrouck (2005) argues that the Amihud measure is among the best liquidity proxies that can be constructed from low frequency data and are highly correlated with proxies constructed using transaction data. He suggests a modified version of the Amihud measure to smooth over extreme values, which is

$$\text{Illiquidity}_{im} = \frac{1}{D_{im}} \sum_{d=1}^{D_{im}} \sqrt{\frac{|r_{id}|}{\text{Volume}_{id}}}. \tag{3}$$

This is the version we adopt in this paper. We use CRSP data to construct this stock illiquidity measure.

B.2. Results

Table V presents the analysis on liquidity spillover from the stock market to the CDS market. It shows that CDS spreads are higher when the reference entity's stock is less liquid. The economic significance is remarkable: a one standard deviation (0.033) increase in stock illiquidity is associated with 39.6 bps increase in CDS spreads. Furthermore, including stock illiquidity slightly increases the coefficient estimate and statistical significance of CDS illiquidity (NQT). Therefore, liquidity spillover from the stock market to the CDS market is more likely through a direct impact of stock illiquidity on CDS spreads. This result is also consistent with the capital structure arbitrage scenario that in order to successfully implement an arbitrage strategy, both stock and CDS market liquidities are critical.

C. Liquidity Spillover from the Stock Option Market

C.1. Option Liquidity Proxies

Option liquidity is measured by bid-ask spread, trading volume, and open interest. Options are standard securities. Bid-ask spread measures trading costs that compensate market makers for the risk of adverse selection and hedge costs. Trading volume measures market activity may or may not be due to private information or difference in opinion, because of the hedging role options play. Open interest provides key information regarding both market activity and differential information of an option. When options have a large open interest, it means they have a large number of buyers and sellers, and an active secondary market will also increase the odds of getting option orders filled at good prices. So, all other things being equal, the bigger the open interest, the easier it will be to trade that option at a reasonable spread between the bid and the ask.

C.2. Results

Table VI presents evidence of liquidity spillover from the option market to the CDS market. The overall finding is similar to that in the previous section on liquidity spillover from the stock market to the CDS market. This is expected as stocks and options are close substitutes in capital structure arbitrage, therefore they should play similar roles. First, option trading volume is negatively significantly associated with CDS spreads. The economic significance is also notable: a one standard deviation (1.95) increase in option volume (in log) is associated with 8.4 bps decrease in CDS spreads. Option bid-ask spread is insignificant because it measures more of trading costs rather than liquidity. Option open interest is insignificant by itself but significantly *positive* when included with option volume, very likely due to multicollinearity between trading volume and open interest (the correlation between volume (in log) and open interest (in log) is 0.94). Also, including option illiquidity proxies slightly increases the coefficient estimate and statistical significance of NQT, consistent with the capital structure arbitrage scenario as we discussed in the previous subsection.

VI. Time Variation in Liquidity and Liquidity Spillover Effects

the CDS market is still at its early stage compared to other derivative markets. Given its rapid growth, we should observe some time variation in liquidity effects as the market develops into a more mature one. We expect the market to be more and more liquid. The market will be more integrated with other markets than before.

Our first evidence of improving liquidity in the CDS market is from CDS market trading costs. As shown in Figure 3, market average bid-ask spread has decreased significantly, from the high of around 50 basis points before year 2003 to around 10 basis points more recently.[13] Because the set of issuers change over time, we also plot the percentage bid-ask spread (bid-ask spread divided by mid quote) in Figure 4, we still observe some evidence that percentage bid-ask spread has declined, although there is a sharp increase in year 2005.

We investigate the time variation in the explanatory power of liquidity for CDS spreads. In each month, we regress CDS spreads on liquidity proxies only in the cross-section. We do not include other determinants of CDS spreads in order to capture the pure explanatory power from liquidity proxies. We expect the explanatory power of liquidity (both own market liquidity and other market liquidity) to decrease as the market develops.

We expect CDS market liquidity to have less impact on CDS spreads as the market environment improves. Figure 5 plots the time-series of R^2s from the regression of CDS spreads on all liquidity proxies. The overall evidence is clear. The explanatory power of liquidity has decreased since the beginning of year 2000. At the beginning of the market, liquidity and liquidity spillover explain around 60 percent of the cross-sectional variations in CDS spreads. In more recent times, the R^2 has dropped to the 30 percent level. Admittedly, it is difficult to judge the statistical significance of the magnitude of this decrease without a formal testing. On average, liquidity explains around 40% of the cross-sectional variations in CDS spreads.

[13]The low bid-ask spread at the very beginning of the period may be driven by higher quality of issuers. It is conceivable that only high quality issuers are selected to be traded at the experimental stage of a market.

VII. Conclusions

Information is key to price formation. Incomplete information and asymmetric information are universal phenomena. The effect of liquidity on asset prices is well understood in other markets. In this paper we show that liquidity factors are significant predictors for CDS spreads. We find both CDS market illiquidity and illiquidity spillover from stock and option markets explain a substantial portion of credit spreads. We estimate a liquidity premium of 9.3 basis points in CDS spreads, on par with Treasury bond liquidity premium and nondefault component of corporate bond yield spreads. Liquidity proxies alone explain around 40% of the cross-sectional variations in credit spreads. We find some evidence that the effect of liquidity on CDS spreads varies over time. It has less explanatory power in more recent time.

This study adds liquidity concern to the list of "unresolved issues" in the pricing of CDS discussed by Turnbull (2005). Our findings highlight the need of CDS pricing model taking liquidity premium into account. This study takes a pure empirical or atheoretic approach and implicitly assumes constant liquidity premium. Future study can bring our empirical findings to a coherent CDS valuation model. In the imperfect liquid CDS market, supply curve for CDS contracts may be a function of the order flow, along the line of Cetin, Jarrow, Protter, and Warachka (2005) on option pricing with illiquidity.

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Table I
CDS Data Summary Statistics

This table reports pooled time-series and cross-sectional year-by-year summary statistics of monthly average CDS spreads in basis points from June 1997 to April 2005. Data is from a major CDS broker. This sample selects only non-sovereign US bond issuers denominated in US dollars with reference issue ranked senior unsecured and maturity around five years. Intradaily quotes and trades are aggregated to obtain monthly average CDS spreads.

		Rating Groups						
		AAA	AA	A	BBB	BB	B	NR
1997	N	4	6	20	13	5	1	–
	Mean	23.50	24.00	40.17	37.50	71.00	120.00	–
	Stdev	10.79	18.53	41.68	11.69	38.79	–	–
1998	N	6	39	119	49	11	–	6
	Mean	38.44	38.35	33.84	54.52	73.41	–	44.11
	Stdev	25.63	32.56	18.66	40.75	47.03	–	14.89
1999	N	9	73	238	139	12	–	17
	Mean	38.95	30.15	34.64	70.99	59.82	–	49.08
	Stdev	23.54	15.67	17.30	44.79	18.06	–	28.06
2000	N	15	83	326	377	56	15	14
	Mean	57.27	42.26	55.28	130.60	220.07	388.27	166.59
	Stdev	31.13	30.25	38.98	109.80	125.95	125.36	171.75
2001	N	24	139	523	625	116	28	16
	Mean	42.68	53.78	84.42	172.40	376.51	596.90	216.47
	Stdev	27.47	37.61	49.93	106.72	151.04	243.97	151.63
2002	N	39	151	808	1106	176	20	33
	Mean	67.82	67.88	101.83	213.63	481.41	642.20	250.38
	Stdev	51.95	58.34	77.13	172.56	236.02	322.55	254.37
2003	N	58	82	776	1220	220	75	15
	Mean	35.08	30.15	59.06	126.62	362.32	573.91	129.83
	Stdev	33.45	25.19	56.24	104.33	183.34	293.44	87.59
2004	N	51	98	491	965	245	61	211
	Mean	15.19	24.97	40.79	73.32	182.46	329.81	116.33
	Stdev	9.14	8.91	38.84	47.14	111.57	170.76	116.10
2005	N	8	18	98	285	91	19	185
	Mean	11.82	18.90	30.07	48.16	102.15	236.40	79.04
	Stdev	3.80	7.37	46.53	38.56	55.14	92.62	80.32

Table II
CDS Illiquidity and CDS Spreads

This table shows the effects of CDS illiquidity on CDS spreads. Shown in the table are panel regression results. The dependent variable is monthly average CDS spreads. Monthly dummies (not shown) are also included in the regressions. OIV is at-the-money option-implied volatility. Jump is the difference implied volatility between at the money option and in-the-money option. NQT is number of quotes and trades within the month for the reference issue. Order imbalance is the absolute difference between number of buyer initiated quote or trade and seller-initiated quote or trade. % B/A is the percentage CDS bid-ask spread. Issuer-clustering is adjusted to obtain robust t-values.

	(1)		(2)		(3)		(4)	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Constant	419.22	7.19	416.98	7.15	533.08	7.81	536.97	7.90
OIV	492.25	14.59	496.13	14.92	509.40	13.12	502.14	12.68
Jump	734.24	4.07	734.07	4.03	624.69	3.03	620.95	3.07
Credit Rating	-23.67	-12.16	-23.67	-12.14	-25.52	-11.37	-25.69	-11.51
Leverage	83.19	5.02	83.44	5.01	84.89	4.25	87.15	4.46
B/M	0.00	-12.00	0.00	-12.06	16.94	1.39	16.08	1.34
Market Cap	32.11	4.86	32.58	4.87	41.58	5.01	41.11	5.08
NQT	0.09	2.55					0.11	3.60
Order Imbalance			0.57	1.58			-0.01	-0.06
% B/A					30.52	1.80	41.10	2.56
N	8704		8704		6138		6138	
Cluster	497		497		440		440	
Adj-R^2	0.598		0.597		0.613		0.615	
F	29.52		28.97		18.31		22.57	

Table III
Illiquidity and Credit Risk

This table shows the effects of CDS illiquidity on CDS spreads by credit ratings. Shown in the table are panel regression results. The dependent variable is monthly average CDS spreads. Monthly dummies (not shown) are also included in the regressions. OIV is at-the-money option-implied volatility. Jump is the difference implied volatility between at the money option and in-the-money option. NQT is number of quotes and trades within the month for the reference issue. Issuer-clustering is adjusted to obtain robust t-values.

	AA		A		BBB		BB	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Constant	-45.40	-4.48	-29.55	-2.51	-194.05	-12.60	-162.62	-2.56
OIV	196.32	4.49	156.07	5.00	563.30	11.61	499.87	7.24
Jump	-653.40	-1.16	342.40	1.25	750.61	3.84	1017.39	1.96
Leverage	-39.31	-2.72	-9.36	-0.85	176.22	7.95	193.58	2.71
B/M	66.27	6.73	29.65	1.82	0.00	-10.88	0.74	0.04
Market Cap	-4.39	-0.12	-2.94	-0.51	-25.36	-0.88	-88.84	-0.77
NQT	0.26	1.87	0.18	3.55	0.16	4.00	0.20	1.09
N	611		3176		4002		639	
Cluster	38		188		269		111	
Adj-R^2	0.446		0.312		0.562		0.561	
F	6.51		16.01		55.56		12.03	

Table IV
Illiquidity Spillover from Bond Market to CDS Market

This table shows the effects of illiquidity spillover from bond market to CDS market on CDS spreads. Shown in the table are panel regression results. The dependent variable is monthly average CDS spreads. Monthly dummies (not shown) are also included in the regressions. OIV is at-the-money option-implied volatility. Jump is the difference implied volatility between at the money option and in-the-money option. NQT is number of quotes and trades within the month for the reference issue. Bond age (maturity) is the average age (maturity) of all bonds outstanding for the reference entity. Bond Amt is the total principal amount of bond outstanding for the reference entity. Issuer-clustering is adjusted to obtain robust t-values.

	(1)		(2)		(3)		(4)	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Constant	507.96	8.21	500.21	8.52	349.40	5.96	511.95	8.74
OIV	523.51	12.61	527.06	12.86	526.94	12.78	524.20	12.83
Jump	610.15	3.80	573.50	3.48	635.17	3.80	574.56	3.52
Credit Rating	-21.99	-10.65	-22.58	-11.31	-21.48	-10.85	-22.60	-11.39
Leverage	62.63	3.34	65.80	3.76	73.60	3.79	73.23	3.91
B/M	10.28	0.80	9.61	0.76	6.68	0.54	8.89	0.70
Market Cap	33.73	3.21	38.35	3.72	35.03	5.05	44.40	4.35
NQT	0.05	1.73	0.05	1.71	0.06	2.13	0.05	1.65
Bond Age	-1.53	-1.16					-1.78	-1.37
Bond Maturity			0.98	2.17			0.92	2.01
Bond Amt					-0.33	-2.06	-0.36	-1.97
N	7401		7401		7540		7401	
Cluster	403		403		406		403	
Adj-R^2	0.594		0.596		0.597		0.598	
F	26.81		40.23		26.26		29.72	

Table V
Illiquidity Spillover from Stock Market to CDS Market

This table shows the effects of illiquidity spillover from stock market to CDS market on CDS spreads. Shown in the table are panel regression results. The dependent variable is monthly average CDS spreads. Monthly dummies (not shown) are also included in the regressions. OIV is at-the-money option-implied volatility. Jump is the difference implied volatility between at the money option and in-the-money option. NQT is number of quotes and trades within the month for the reference issue. Stock illiquidity is the daily average of square root absolute return to volume ratio. Issuer-clustering is adjusted to obtain robust t-values.

	Coef.	t-stat
Constant	458.18	6.69
OIV	484.46	14.31
Jump	356.80	1.81
Credit Rating	-21.50	-10.99
Leverage	78.22	5.01
B/M	0.00	-12.70
Market Cap	38.43	5.23
NQT	0.12	3.55
Stock Illiquidity	1189.18	4.39
N	8652	
Cluster	495	
Adj-R^2	0.608	
F	30.15	

Table VI
Illiquidity Spillover from Stock Option Market to CDS Market

This table shows the effects of illiquidity spillover from stock option market to CDS market on CDS spreads. Shown in the table are panel regression results. The dependent variable is monthly average CDS spreads. Monthly dummies (not shown) are also included in the regressions. OIV is at-the-money option-implied volatility. Jump is the difference implied volatility between at the money option and in-the-money option. NQT is number of quotes and trades within the month for the reference issue. Option B/A is option bid-ask spread. Option O/I is the open interest (in log). Issuer-clustering is adjusted to obtain robust t-values.

	(1)		(2)		(3)		(4)	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Constant	533.17	7.85	515.25	7.20	541.30	8.10	439.85	6.20
OIV	517.82	15.18	498.36	14.87	500.91	14.97	513.77	15.22
Jump	639.46	3.39	710.40	3.96	707.09	3.90	556.02	2.90
Credit Rating	-22.73	-11.17	-23.44	-11.91	-23.33	-11.54	-22.67	-11.48
Leverage	84.58	5.18	82.73	4.95	83.63	4.98	81.30	5.04
B/M	0.00	-12.49	0.00	-11.78	0.00	-11.94	0.00	-10.72
Market Cap	39.32	5.14	33.49	4.99	34.45	4.78	35.75	5.04
NQT	0.11	3.36	0.10	2.85	0.10	2.87	0.10	3.04
Option Volume	-4.33	-2.33					-17.35	-5.66
Option B/A			51.36	1.54			45.10	1.37
Option O/I					-1.50	-0.74	16.13	4.65
N	8652		8652		8652		8652	
Cluster	495		495		495		495	
Adj-R^2	0.599		0.597		0.597		0.603	
F	28.55		30.52		28.35		31.63	

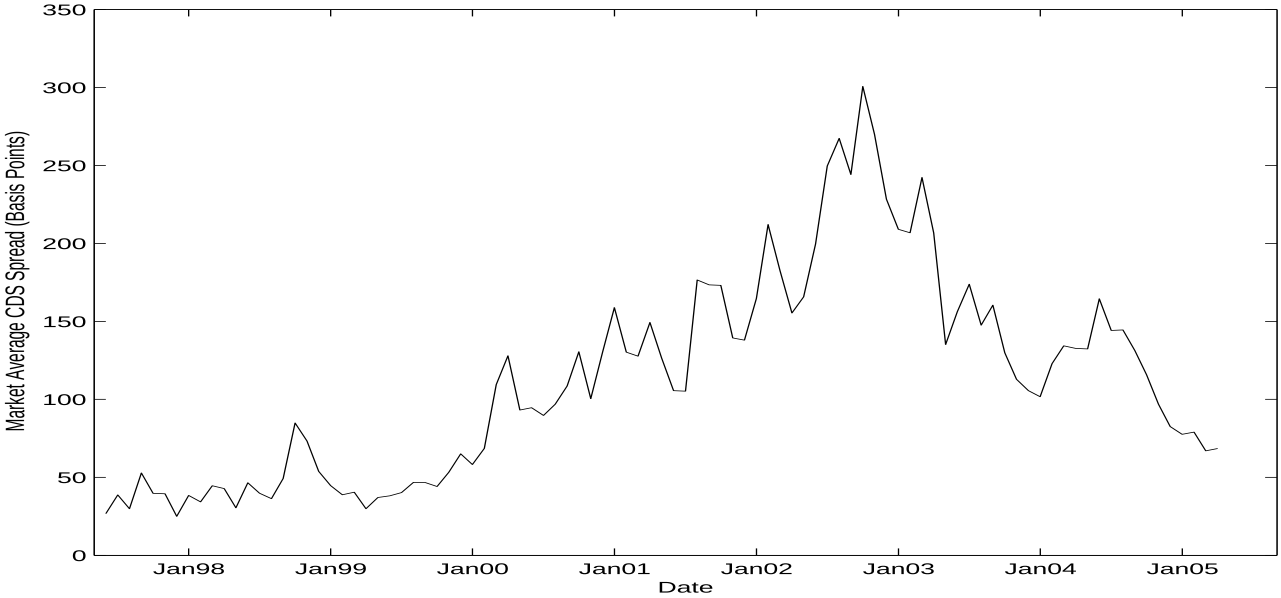

Figure 1. Market average CDS spreads.
The sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds and maturity around 5 years, from one CDS broker.

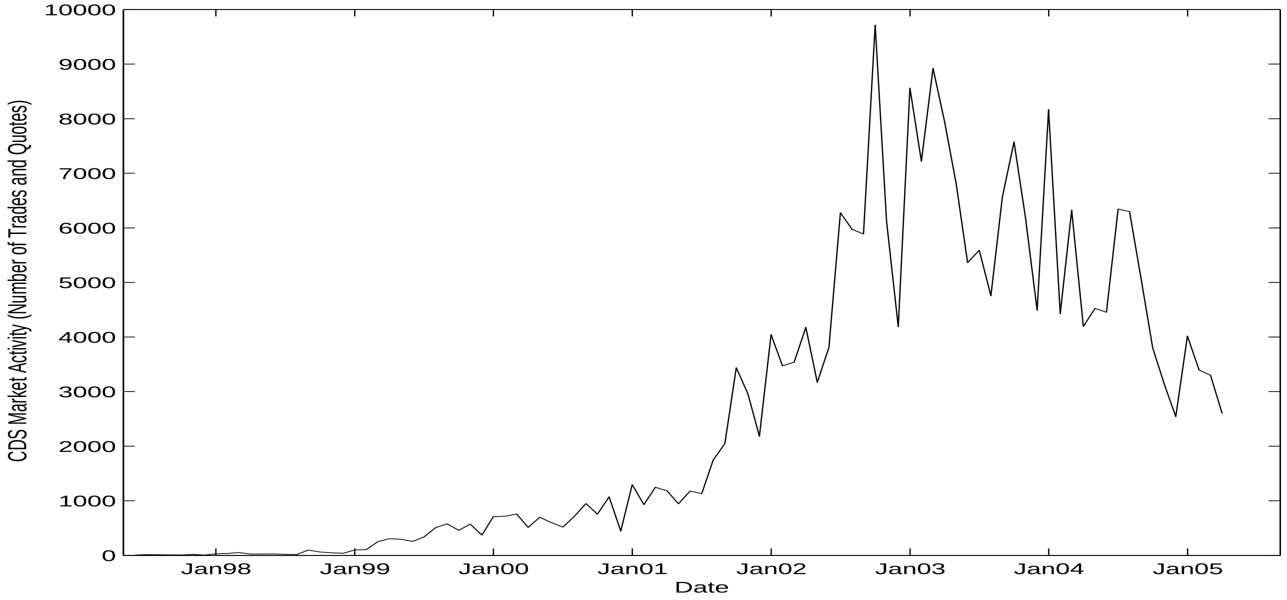

Figure 2. Total number of quotes and trades in the sample.
The sample includes only U.S. dollar denominated contracts for U.S. corporations with reference issues being senior unsecured bonds and maturity around 5 years, from one CDS broker.

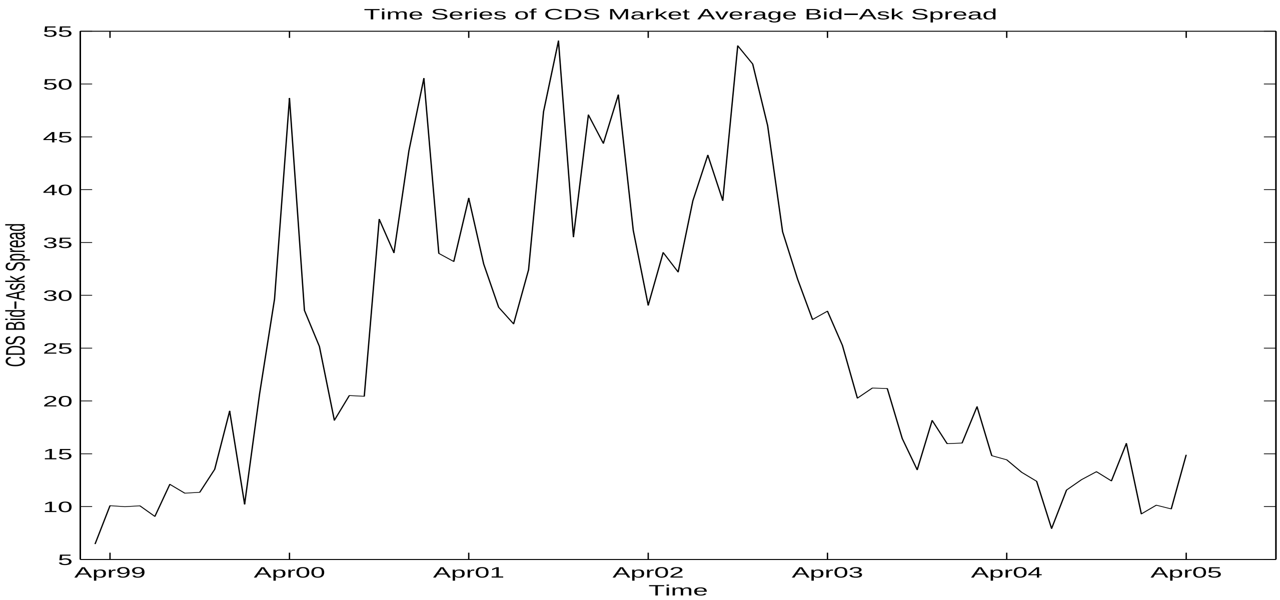

Figure 3. Time-series plot of CDS market average bid-ask spread.

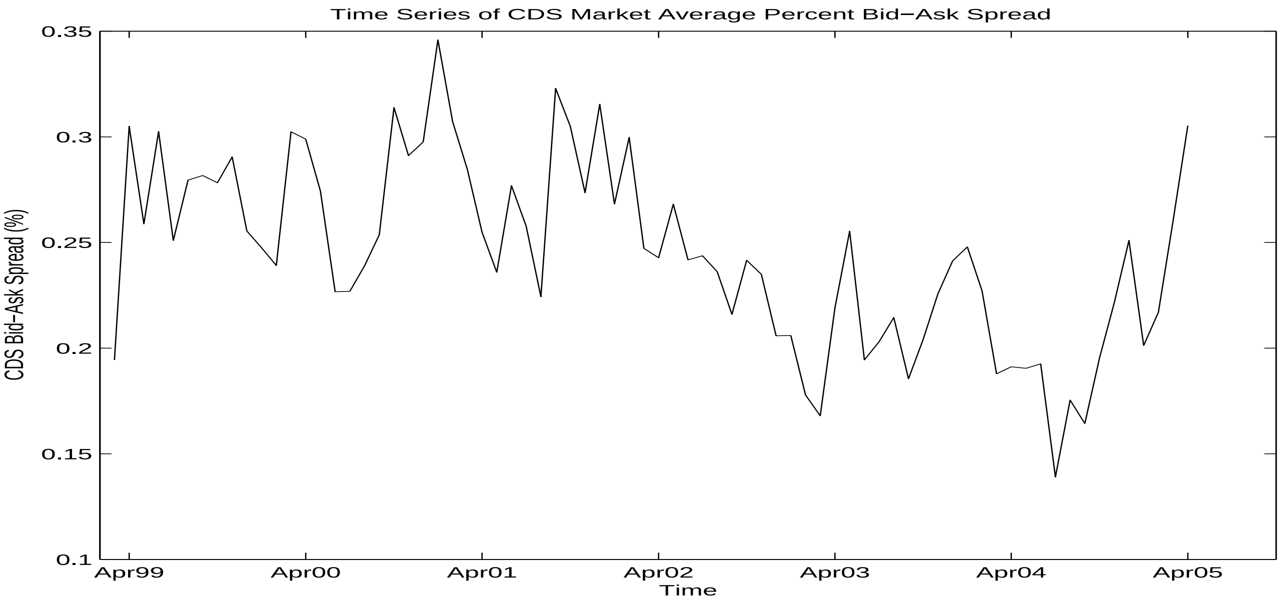

Figure 4. Time-series plot CDS market average percentage bid-ask spread.

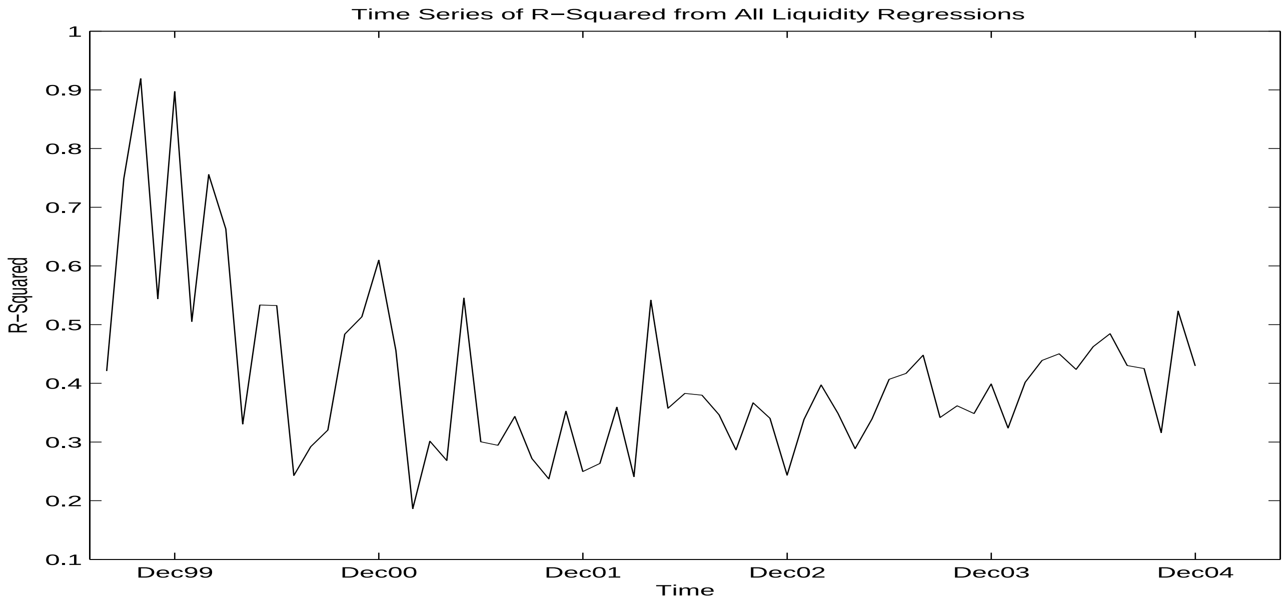

Figure 5. Time-series plot of R^2 from regressing CDS spreads on all liquidity proxies.